A Multi-Disciplinary Investigation of the Nature and Predictability of Sediment Resuspension in Shallow Water: Its Effect on Water Column and Bottom Optical Properties

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LONG-TERM GOALS

Our group is working towards an understanding of the forcing mechanisms on the inner west Florida shelf for particle erosion, vertical particle mixing, and sedimentation as well as the effects of these processes on the optical properties of the water column in terms of remote-sensing. We are relying upon the use of innovative sensor and sampling methodologies that provide synergy among the

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following: optical and acoustical measurements of the distribution of suspended sediment, bottom albedo and microtopography, bottom type, bedforms, hydrodynamics, and particle dynamics. Measurements of forcing, observed both locally and from as far away as 60 km, will be related to observations of suspended particles and optical properties to evaluate short-term predictions of erosional potential, suspended sediment distributions, and the effect on the optical properties of the water column.

OBJECTIVES

Our primary objective is to provide ground truth data to aid in the calibration of optical sensors to benefit remote sensing data interpretation in nearshore environments. This objective is being met by defining the nature of the seafloor and water column reflectance, including components such as bathymetry, sediment grain size and mineralogy (on the seafloor and in suspension), amount of organic versus mineral material in suspension, suspended sediment sources, processes controlling water column turbidity, and the temporal and spatial evolution of turbidity.

APPROACH

In order to aid in the calibration of satellite optical remote sensing data, we are quantifying sediment resuspension activity on the inner continental shelf off west-central Florida (Figure 1)--an area that offers the benefit of previous, ongoing, and additional proposed work beyond ONR efforts (USGS, State of Florida, and NOAA). This project is part of a collaborative effort with other investigators (i.e., Carder and Luther, 1999, and Weisberg and Costello, 1999) and other agencies.

We are approaching this work along two avenues: (1) the geologic product, and (2) the sedimentary process. The geologic products are defined as the bathymetric, textural, and sedimentologic variations on the seabed and the size and type of sediments that are actually resuspended. The sedimentary processes are those physical motions that suspend sediments that were originally at rest on the seabed, and advect sediments laterally from other sources. This component also includes a quantification on how the seabed is disturbed and instrument-based measurements of suspended sediment concentrations.

WORK COMPLETED

Multibeam bathymetry surveys were conducted during a research cruise aboard the R/V Bellows (Florida Institute of Oceanography) during February 1999 (Figures 1 and 2). Surveys were conducted to provide high-resolution bathymetric and backscatter intensity data for mosaics using our Simrad EM3000 multibeam sonar system. Areas targeted for the mosaics included the vicinity of Navy moorings NA111 and NA121, and Ecohab moorings ECO141 and ECO151. Shore-normal tie lines were also suveyed between mosaic areas. Bathymetric data have been processed (Figure 2) and have been provided to EcoHAB participants. Although a side-scan survey was scheduled for September, hurricane activity and equipment problems resulted in the postponement of the cruise.

The upgrade of existing USGS sonar towers (used in previous ONR-sponsored AUV experiments) with a suite of acoustic and optical sensors to better measure the bottom boundary layer characteristics and their effects on sediment resuspension is undergoing final bench tests as of this writing. Delays

resulting from unanticipated difficulty with synchronization of sampling from the 7 different sensors, unexplained power draw and data storage requirements have occurred. These issues now appear to be resolved and deployment has been tentatively scheduled for mid-December, 1999. These towers will have an intense concentration of sensors in a vertical array covering the bottom two meters of the water column, providing measurements of hydrodynamics and suspended sediment concentrations as close to the bed as possible with current technology. The shear stress affecting the bed is estimated using the vertical array of Sontek ADV Ocean three-axis Acoustic Doppler Velocimeters (ADV). These sensors allow calculation of the vertical gradient in horizontal velocity in the boundary layer. A high-resolution pressure sensor is also deployed with each Sontek array to provide wave height information necessary for estimation of the wave boundary layer thickness and wave frequency-directional spectra. Co-located optical backscatter suspended sediment sensors (OBS) are used to calibrate the amplitude of the acoustic return, thus providing an additional measure of suspended sediment flux. As both acoustic and optical backscatter sensors are sensitive to the size distribution of the sediments, a Sequoia Instruments LISST 100 is mounted on each. The towers are collocated with ADCPs.

The calculation of bed shear stress from hydrodynamic measurements is highly dependent on the bed roughness, or friction coefficient. Local bottom roughness is measured directly using imaging and profiling rotary side-scan sonar heads on each tower. Profiling sonars have been shown to provide information on the spatial distribution of locally resuspended sediment. The profiling sonar has a vertical resolution of better than 1 cm, so will also be used to quantify erosion of the bed and subsequent redeposition of sediments during resuspension events.

As demonstrated in our recently completed USGS sonar tower deployment at Indian Rocks Beach, the Sontek and OBS sensors can be sampled at 25 Hz. This sampling rate is sufficient to provide an estimate of locally generated turbulence and turbulent transport component of local sediment resuspension. Differentiating between the resuspension effects of waves and currents is accomplished by providing for continuous sampling in 34.1 minute bursts to measure a statistically significant number of waves.

RESULTS

The multibeam data are still being post-processed to remove artifacts and to integrate the data to a uniform vertical reference frame using a base station. The multibeam bathymetric and backscatter intensity data reveal the nature of the bottom boundary layer (e.g. bathymetry, relief, bedforms, sediment distribution) within the study area (Figure 2).

IMPACT/APPLICATIONS

These data are the first in a series of geophysical, sedimentological, and physical oceanographic data to be collected within the study area. The bathymetry from these surveys will provide the template upon which physical oceanographic processes will be modeled, and sediment resuspension and transport can be evaluated. Additionally, data from these surveys will be used to identify optimum sites for deployment of bottom mounted instruments. Data will also be used to verify and calibrate estimates of water bathymetry based on remote sensing techniques, such as LIDAR or Altimetry, and will be made

available to other HyCODE investigators upon request. Some data near the Egmont Key area have been forwarded to Dr. Walt Smith (NRL, SSC)

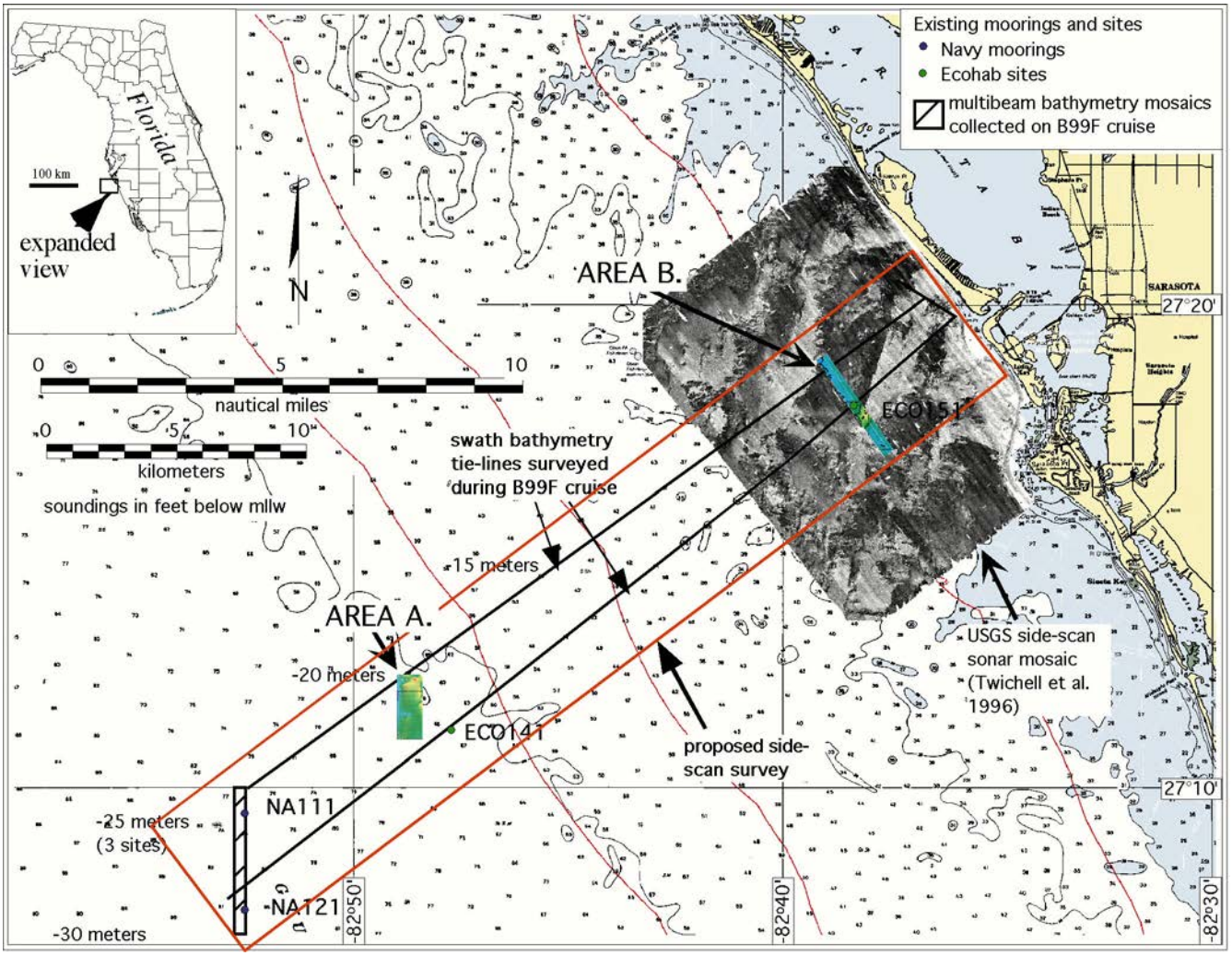

Figure 1. Map showing the location of multibeam bathymetry surveys performed during FY99, physical oceanographic moorings, and existing and proposed side-scan sonar surveys. Bathymetric mosaics at areas A and B are shown in greater detail in Figure 2.

TRANSITIONS

These data are being used by EcoHab/HyCODE investigators to aid in computer modeling of shelf circulation patterns, and to evaluate optical remote sensing data (Weisberg and Luther, 1999; and Carder and Costello, 1999).

RELATED PROJECTS

Weisberg and Luther (1999) are modeling circulation on the West Florida Shelf and will utilize our bathymetric data

Carder and Costello (1999) are measuring optical properties of coastal waters and will be utilizing our bathymetric and sedimentologic data.

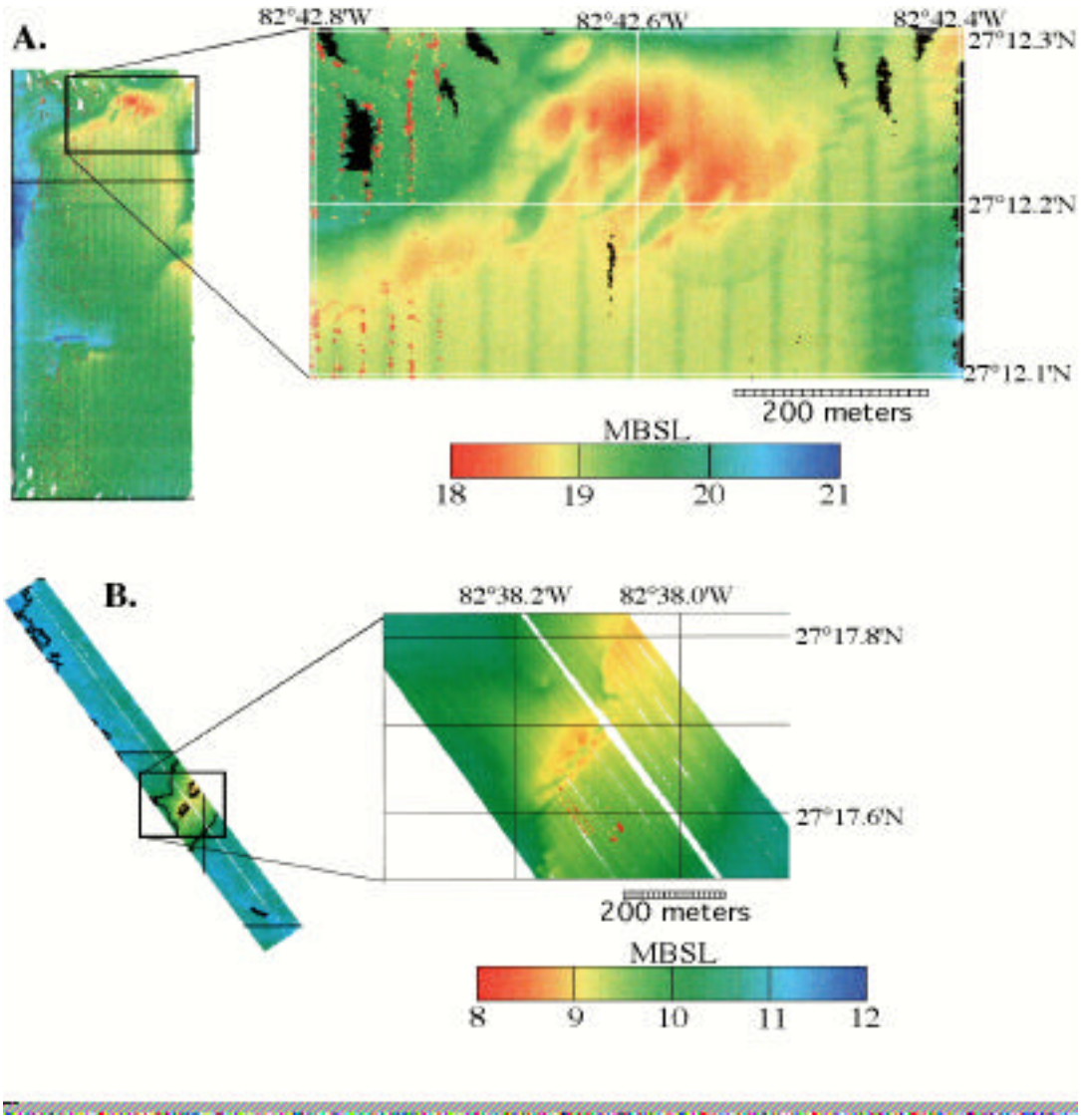

Figure 2. Multibeam bathymetry mosaics acquired within the study area using a Simrad EM3000 system. See Figure 1 for the location of areas A and B.

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Carder, K., and D. Costello, 1999, An investigation of the optical properties of coastal waters using unmanned underwater vehicles, a network of moored sensor packages and remote sensing data: A Research Proposal Submitted to the Office of Naval Research in response to BAA 99-021.

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